RAISING PRODUCTION EFFICIENCY

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HARDENING OF PARTS OF GLASS-SHAPING MACHINES USING TITANIUM NITRIDE

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The principles of deposition of titanium nitride coatings on parts of glass-shaping machines using ion bombardment in vacuum are considered. Results of industrial testing of parts and tools are described.

Various methods are used to increase the wear resistance and efficiency of machine parts. These methods for improvement of the surface properties of a material include the application of special strengthening coatings, such as carbides, nitrides, and other high-melting wear-resistant compounds.

A method that is currently widely used for surface hardening of metal-cutting tools consists in the deposition of wear-resistant coatings by ion bombardment in vacuum (CIB). The effectiveness of the CIB technology is determined by a number of factors, of which its universality and the high-strength adhesive bonds between the coating and the metal surface are of primary significance. The adhesive bonds in this method are provided by preliminary ion bombardment of the surface that requires hardening, and heating of the surface to high temperatures. The most common wear-resistant coating hardened by the CIB method is a layer of nitride titanium, which has high strength and corrosion resistance. The deposition of such coatings is performed on industrial installations, for example, the NNV-6.6 I1.

The Research and Development Institute of Glass carried out an investigation to test the efficiency of a hardening titanium nitride coating for parts of glass-molding machines: neck rings, punches, shears for cutting glass melt drops. In service these parts are subjected to the most intense wear and constantly need replacement.

The titanium nitride coating was deposited on the specified parts using an NNV-6.6 I1 installation. The technology of depositing a hardening coating envisioned for the installation was slightly modified: the surface of a machine part was previously treated by bombardment with neutral nitrogen atoms.

In the standard technology of deposition of hardening coatings by the CIB method, the cleaning and preheating of the tool surface are carried out by ion bombardment before applying the coating, and in doing so, the surface layers of the treated tool are etched. In the course of ion bombardment, the tool surface is doped with the bombarding metal ions, i.e., a surface alloy is formed [1].

It is shown in [2] that the reaction of the metal from the ionized flow with the components of the part material proceeds under conditions of diffusive redistribution of carbon in them, which leads to the formation of bombarding-metal carbides in surface alloys, in particular, titanium carbide is formed when titanium is used as the bombarding metal. Here, diffusion of carbon from the steel machine part into the growing layer of condensed titanium continues up to 10 μm.

As titanium nitride is condensed on the part surface, mutual diffusion of carbon into the titanium nitride layer and of nitrogen into the tool material proceeds with the formation of an intermediate titanium carbonitride layer.

In order to increase the thermodynamic stability of the coating, the authors of [3] propose to induce condensation of the coating on top of a special surface alloy whose reacting capacity with respect to the coating is low. This is exactly the surface layer that is formed under the bombardment of steel or iron machine parts by neutral nitrogen atoms.

Moreover, preliminary treatment of the part surface by neutral nitrogen atoms reduces the quantity and intensity of micro-arcs in subsequent ion bombardment of the surface, which preserves the high quality of the surface and prevents blunting of cutting edges.

In the course of the investigation, the conditions for preparing a part surface for coating deposition and the temperature fluctuations in the part during ion bombardment and coating application were clarified. The latter is especially significant, since the wear resistance of a coated part depends not only on the coating microhardness, but on the hardness of

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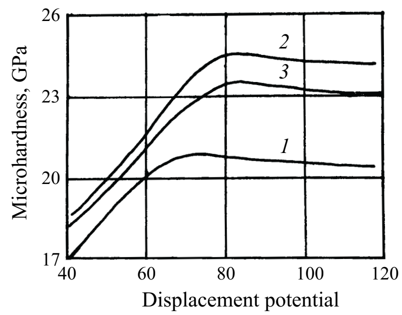

Fig. 1. Variation in the microhardness of a TiN_x coating as a function of the displacement potential under a nitrogen pressure of 25 (*1*), 40 (*2*), and 55 MPa (*3*).

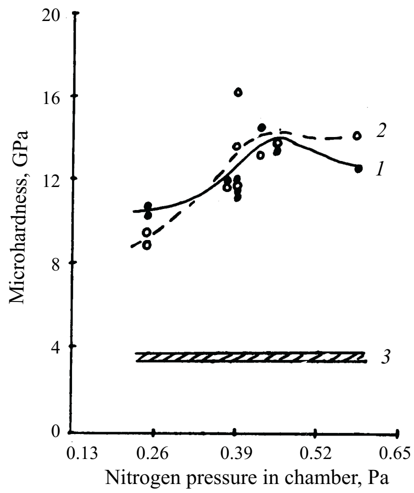

Fig. 2. Dependence of the effective microhardness of a TiN_x coating on the nitrogen pressure in the reaction chamber: *1* and *2*) steel and cast iron plates with a coating, respectively; *3*) cast iron and steel plates before treatment.

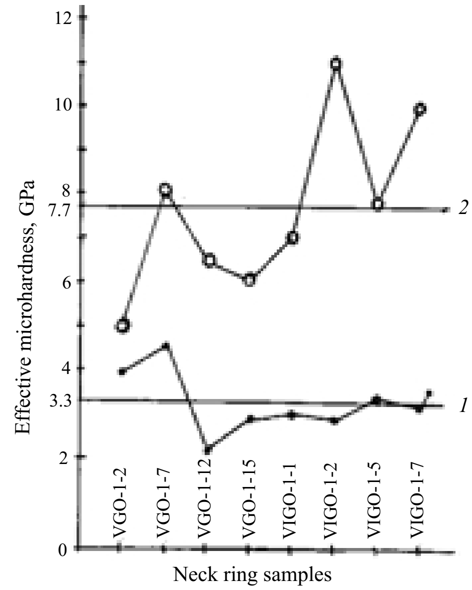

Fig. 3. Effective microhardness of the working surface of neck rings before (*1*) and after (*2*) deposition of a hardening coating.

the part material as well. Therefore, such parts as punches were tempered before the deposition of the coating.

Thus, we had to solve the problem of ion bombardment of the specified parts and subsequent coating deposition within a narrow temperature range (50°C) that was bounded on one side by a satisfactory degree of material adhesion and on the other side by the tempering temperature. The same problem was solved for thin-walled tools, namely, shears for cutting off a glass melt drop, the only difference being the need to prevent undesirable overheating of the tool cutting edges. In solving these problems, one had to identify intensity values for ion bombardment and coating deposition such that the whole process could occur within the preset narrow temperature interval.

The microhardness of the coating largely depends on the stoichiometry of the obtained TiN_x coating and, accordingly, on the pressure of nitrogen in the chamber during the coating formation.

Paper [4] described the dependence of the coating microhardness on the pressure inside the Pusk installation chamber (Fig. 1). As is seen, this relationship has a maximum related to a particular pressure value that is typical of the particular installation.

To determine the microhardness of the coating as a function of the nitrogen pressure in the chamber, an experiment was carried out in which coatings 4 μm thick were deposited on cast iron and steel plates 30 × 30 × 5 mm in size. The microhardness of the plates before the coating deposition and the effective microhardness of the coated plates were determined in this investigation.

The need to soeak of the effective microhardness of a coating deposited on a plate is caused by the fact that the microhardness determined by pressing a diamond indenter can be regarded as absolute only when the indentation diagonal is 2 – 3 times smaller than the coating thickness [15]. In our case (the measurements were performed on a PTM-3 hardness gauge), the indentation diagonal under a 5-g load exceeded the coating thickness by 2 – 2.5 times. Therefore, the microhardness of the coating was an effective value related to the hardness of the machine part and could not reach the absolute microhardness values of the coating itself, which amounted to 20 – 24 GPa.

It can be seen in Fig. 2 that the microhardness of the plate surface after deposition of a coating 3 – 5 μm thick increases 2.5 – 3 times, and the maximum microhardness values correspond to the TiN_x coating formed when the nitrogen pressure in the chamber is 0.46 Pa.

Under the indicated nitrogen pressure, conditions for applying titanium nitride coatings 4 μm thick on massive (punches, neck rings) and thin-walled (shear blades for cut-

ting glass melt drops) parts of glass-shaping equipment were developed and tested, taking into account the tempering temperature of the machine part material. It is shown in Fig. 3 that the effective microhardness of the neck rings after deposition of the coatings increased 2 – 3 times.

All parts hardened by a titanium nitride coating were tested in production at the Experimental Glass Factory. It was established that the hardening coating withstands contact with fluid glass under the operating conditions and preserves its outer appearance and its initial hardness.

Parts with a hardening coating were removed from the production process in the following cases:

– parts became unfit for service as a consequence of emergency operating conditions;

– the carbon deposit had to be removed, while the tool and the coating retained their integrity;

– the part had to be restored, since the coating and the part itself were worn at loaded segments of the surface and the edges.

The service life of parts with a hardening coating is perceptibly longer. Thus, testing at the Experimental Glass Factory demonstrated that coated shear blades appropriately prepared and installed withstood 1250 – 1750 thousand glass drop cuts before sharpening, whereas noncoated shear blades required sharpening after 360 thousand cuttings. The service life of punches before machining was increased 3 – 5 times.

Implementation of this technology in glass production generates a substantial economic effect and makes it possible to improve glass product quality.

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